

SECTION 15700

HEATING, VENTILATING, AND COOLING SYSTEM

PART 1 - GENERAL

1.1 REFERENCES

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.
1. Association of Home Appliance Manufacturers (AHAM)
 2. Air Movement and Control Association, Inc. (AMCA)
 3. American National Standards Institute (ANSI)
 4. Air-Conditioning and Refrigeration Institute (ARI)
 5. American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc. (ASHRAE)
 6. American Society of Mechanical Engineers (ASME)
 7. American Society of Sanitary Engineering (ASSE)
 8. American Society for Testing and Materials (ASTM)
 9. ETL Testing Laboratories (ETL)
 10. Foundation for Cross-Connection Control and Hydraulic Research (FCCCHR)
 11. Gas Appliance Manufacturers Association (GAMA)
 12. Manufacturers Standardization Society of the Valve and Fittings Industry, Inc. (MSS)
 13. National Electrical Manufacturers Association (NEMA)
 14. National Fire Protection Association (NFPA)
 15. National Roofing Contractors Association (NRCA)
 16. Sheet Metal & Air Conditioning Contractors' National Association, Inc. (SMACNA)
 17. Underwriters Laboratories Inc. (UL)

1.2 SYSTEM DESCRIPTION

Provide new and modify existing heating, ventilating, and cooling (HVAC) systems complete and ready for operation. HVAC systems include equipment, ducts, and piping which is located within, on, under, and adjacent to buildings.

1.3 SUBMITTALS

Submit the following in accordance with section entitled Section 01300 "SUBMITTALS".

A. Manufacturer's Catalog Data

1. Split-system air-conditioners
2. Packaged air-handling units
3. Cabinet unit heaters
4. Unit heaters
5. Exhaust fans
6. Diffusers, registers, and grilles
7. Fire dampers
8. Specialty Valves
9. Dielectric Connections

B. Instructions

1. Installation manual
 - a. Installation Manual

Provide for each item of equipment.

C. Statements

1. Certification of welders' qualifications
 - a. Certification of Welders' Qualifications

Submit copy of Welder Qualification Tests (Form QW-482) prior to site welding. Certification shall not be greater than one year old.
2. Equipment field test plans
 - a. Equipment Field Test Plans

Submit within 120 calendar days after contract award for the following equipment. Submit equipment field test plans to Architect for review and approval.

 - (1) Air-handling units: packaged; greater than 2,000 cfm.
 - (2) Variable air volume (VAV) terminals and related air-handling unit.

D. Field Test Reports

1. Packaged air-handling units: greater than 2,000 cfm

Submit field test reports to Architect for review and approval.

E. Certificates

1. Fire dampers

F. Operation and Maintenance Manuals

1. Split-system air-conditioners
2. Packaged air-handling units
3. Variable air volume (VAV) terminals. Submit with respective air-handling unit.
4. Exhaust fans

Submit in accordance with Section "OPERATION AND MAINTENANCE DATA".

PART 2 - PRODUCTS

2.1 EQUIPMENT

Equipment using refrigerants R-11, R-12, R-113, R-114, R-115, R-500, or refrigerants with ozone depletion factor (ODF) greater than 0.05 shall not be permitted.

A. Split-System Air-Conditioners

Provide units factory assembled, designed, tested, and rated in accordance with ARI 210/240 or ARI 360 for cooling. Provide separate assemblies designed to be used together. Base ratings on the use of matched assemblies. Units shall have a minimum SEER as specified on the drawings when tested in accordance with ARI 210/240 or ARI 360 as applicable. Units shall be ARI certified or rated in ARI UD for cooling. Outside unit shall include compressor and condenser. Provide guards to protect condenser fins. Units shall be listed in UL EAUED or ETL DLP.

1. Filter section: Provide UL listed, 2 inch thick 30 percent efficient throwaway fiberglass filters, standard dust-holding capacity, 350 fpm fiberglass filters, maximum face velocity.
2. Safety controls: Provide low refrigerant pressure protection and pressure relief device. Provide compressor motor with thermal and overload protection, 5 minute anti-recycle timer, and start capacitor kit. Provide compressor with electrical crankcase heater and internal high pressure protection. The above safety controls are not required when scroll compressors are provided.
3. Space temperature controls: Provide digital electronic controls including adjustable programmable thermostats with COOL-OFF-HEAT system switch and AUTO-ON fan switch. Thermostats shall be provided by unit manufacturer.

Provide relays, transformers, contactors, and control wiring between thermostats and unit.

4. Special corrosion protection: Provide condenser coils constructed of copper tubes and plate copper fins or copper tubes and plate aluminum fins with phenolic coating factory applied to entire coil by immersion dipping and baking to 1.5 mil minimum dry film thickness. Rating of units shall be prior to application of phenolic coating.

B. Packaged Air-Handling Units

Provide units factory assembled, designed, tested, and rated in accordance with ARI 430. Units shall be ARI certified for cooling. Provide heating and cooling units including hot water coils and direct expansion refrigerant coils with expansion devices and solenoid valves. Unit shall include fan section, coil section with drain pan, variable frequency motor controller, filter section and access panels. Insulate interior of casing with manufacturer's standard insulation. Provide nylon bushings for dampers.

1. Fan section: Provide draw-through fan section including motor, starter, and drives. Provide adjustable sheaves to permit fan capacity variation from 5 percent above to 5 percent below rated capacity. Provide fan with discharge dampers or variable inlet vanes as indicated.
2. Coil section: Provide ARI 410 coils and slope for drainage. Provide insulated drain pans under cooling coils and valves. Provide direct expansion refrigerant coils with holding charge of dry nitrogen and seal.
3. Filter section: Provide UL listed, 2 inch thick 30 percent efficient throwaway fiberglass filters, standard dust-holding capacity, 350 fpm maximum face velocity. Provide gasketed hinged access panel with quick opening half-twist latches at end of filter rack.
4. Space temperature controls: Provide controls under Section 15901, "SPACE TEMPERATURE CONTROL SYSTEMS".
5. Weatherproof casing: Provide removable gasketed panels designed to exclude driving rain for access to fans, coils, filters, compressors, motors, and controls. Provide weatherproof outside air intake louvers or weatherproof hoods with moisture eliminators.
6. Roof curbs: Provide factory-fabricated galvanized steel roof curbs, wood nailers, insulation, and seal strips in accordance with NRCA RWM curb details for rooftop air-handling units. Roof curbs shall be furnished by unit manufacturer.
7. Equipment selection: Air-handling unit (AHU) manufacturer shall certify the capability of the AHU to perform between the cumulative design minimum and maximum airflows of the variable air volume (VAV) terminals. The AHU submittal selection shall be supported by fan curves clearly annotated showing operating points of the minimum and maximum airflow of connected VAV terminals.

C. Shutoff Boxes

1. General: Furnish and install air terminal units with an integral discharge sound attenuator, primary damper, noise shroud, damper actuator, and velocity controller.
2. Base Unit: The unit casting shall be fabricated from minimum 22 gauge zinc coated sheet steel and use mechanical locking seams to form a leak resistant assembly. Sealant approved for duct use and conforming to NFPA 90A shall be used during construction of the assembly between mating sheet metal parts. The box discharge connection shall be Slip & Drive and shall be integral with the box casing. The casing of the box shall be internally lined with the Anemostat "Fibre-Lok" system, consisting of thermal/acoustical glass fiber with an aluminum laminate facing, minimum 1" thick, with a density not less than 4 1/4 pounds per cubic foot. The aluminum facing shall be exposed to the air stream to prevent airborne fibres. The edges of the insulation shall be sealed by zinc coated steel channels that interlock the adjacent edges of the insulation. The insulation shall conform to NFPA 90A, UL 181, and ASTM C665.

The damper assembly shall consist of a single elliptical blade that requires nominal 60°F rotation from fully opened to fully closed positions. The damper blade shall be mechanically attached to a shaft with either threaded fasteners, or welded. Rivets are not acceptable. The shaft must be a continuous, singular piece running the full inlet diameter and extending through the casing. The damper shall have a tear resistant neoprene lip seal around its perimeter to form a tight air seal for full shut-off. Seals other than neoprene are not approved. The damper shaft shall rotate in nylon, self-lubricating bearings. Damper position shall be indicated on the end of the shaft on the outside of the casing.

3. Hot Water Coils: Where shown on the plans, hot water heating shall be provided by the unit manufacturer. The hot water coils shall be mounted at the discharge of the air terminal unit by the terminal manufacturer, and the air terminal unit/coil assembly shall have a Slip & Drive connection for attachment to the downstream duct work. Coils shall be 1/2" copper tubing mechanically expanded in aluminum fins (not less than 10 fins/inch) to form a tight thermal bond. Refer to the heating schedule for capacities and performance requirements. Sequencing of the primary air flow and water valves shall be coordinated between the air terminal unit manufacturer and the controls contractor. Water control actuators and valves shall be furnished and installed under Section 23 09 23 of the specifications.
4. Sound Levels: Air terminal unit sound power levels shall have been tested in accordance with the most recent ARI 880 test method. Discharge sound levels shall not exceed NC 30 at 0.20 inches w.g. inlet static pressure with 10 DB room absorption. Radiated sound levels shall not exceed NC 25 at 0.20 inches w.g. inlet static pressure. Scheduled Radiated NC levels include attenuation credit for 10 db room absorption and single pass transmission loss through an acoustical ceiling.

D. Cabinet Unit Heaters

Provide units factory assembled, designed, and tested. Units shall include single heating hot water or steam coil, centrifugal fans, three-speed split capacitor motors with integral thermal overload protection, and filters.

1. Filters: Provide UL listed throwaway fiberglass filters, standard dust-holding capacity.
2. Space temperature controls: Provide controls including adjustable room temperature control thermostats with VENT-OFF-HEAT system switch, HIGH-MEDIUM-LOW fan switch, and FAN ONLY switch. When system switch is in OFF position, deenergize automatic valve to stop water flow to coil. Thermostats shall be furnished by unit manufacturer and installed where indicated. Provide relays, transformers, contactors, and control wiring between thermostats, and unit.
3. Horizontal units: Provide concealed, recessed, and cabinet units where indicated.
 - a. Concealed units: Provide unit mounted filter box with track and hinged access doors with latches. Provide supply air discharge with one inch duct collar. Provide return air plenum suitable for bottom or rear return air duct connection as indicated. Provide plenum with duct lining.
 - b. Recessed units: Provide adjustable recessing frame for flush ceiling mounting. Provide hinged bottom panel with latches for access to filters and fan motors. Provide discharge air outlet with one inch duct collar. Provide bottom access panel with stamped return air grille or provide solid bottom access panel and rear return air inlet with one inch duct collar as indicated.
 - c. Cabinet units: Provide hinged bottom panel with latches for access to filters and fan motors. Provide adjustable double deflection or stamped discharge grilles as indicated. Provide bottom or rear stamped return air grille as indicated.
4. Vertical units: Provide recessed and cabinet units where indicated. Provide unit levelers, subbases, and removable front cover for access to filters and fan motors. Provide outside air intake boxes with manual dampers and weatherproof anodized aluminum louvers.
 - a. Recessed unit: Provide removable front cover for access to entire unit. Provide discharge air and return air grilles in front cover.
 - b. Cabinet unit: Provide removable front, side, and top panels. Provide adjustable double deflection or stamped discharge grille as indicated.

E. Unit Heaters (Hot Water)

Provide factory-assembled, propeller or blower type fan unit heaters arranged for horizontal or vertical air discharge as indicated. Each unit shall include steam or hot water coil, fan, electric motor, housing, and air discharge vanes or diffusers. Horizontal discharge type units shall have adjustable deflectors for control of horizontal and vertical airflow. Rotating air deflector assemblies on vertical units where indicated shall be gear driven by separate electric motor and shall rotate when the fan runs. Each unit shall be provided with threaded mounting holes for attaching threaded hanger rods. Fan motor shall be controlled by wall-mounted adjustable thermostat with higher end of scale range

factory set at 75 degree F. Controls shall be automatic of the on-off type. Provide fan selector switches to provide AUTOMATIC-ON-OFF positions.

F. Unit Heaters (Electric)

1. Acceptable Manufacturers

- a. Markel
- b. Modine
- c. Chromolox

2. Construction

- a. Heavy gauge die formed steel housing.
- b. Completely enclosed fan motor and motor guard.
- c. Individually adjustable discharge louvers.
- d. Aluminum finned, copper clad steel sheath heating element.
- e. Low voltage controls complete with 24 V control transformer if required.
- f. Automatic reset thermal cutout, capillary type.
- g. Fan time delay at off cycle to dissipate heat from elements.
- h. UL listed.
- i. Disconnect switch, non-fused, interlocking and meeting NEC requirements.
- j. Integral or remote thermostat as indicated.

G. Exhaust Fans

1. Centrifugal Exhaust Fans (Wall or Roof)

ANSI/AMCA 210 with AMCA seal. Provide centrifugal type exhaust fans with aluminum housing, fan wheel, and bird screen. Motors shall be completely shielded from the airstream. Provide exhaust opening and gravity closing type automatic backdraft dampers. Provide NRCA RWM roof curb for roof mounted exhaust fans as recommended by fan manufacturer. Provide with disconnect and speed controller. Provide v-belt or direct drive exhaust fans as indicated.

2. Utility Set(s)

ANSI/AMCA 210 with AMCA seal. Provide single width, single inlet blower with backward inclined, non-overloading centrifugal wheel constructed of heavy gage

steel. The housing shall be of heavy gage steel with airtight lock seam construction. Provide a weatherhood to protect the motor and drive. Provide direct drive or v-belt driven exhaust fans as indicated. Belt driven fans shall be provided with an adjustable motor plate. Provide with disconnect, manual starter switch, vibration isolators, and backdraft damper.

2.2 ELECTRICAL

A. Electrical Motors, Controllers, Contactors, and Disconnects

Furnish with respective pieces of equipment. Motors, controllers, contactors, and disconnects shall conform to Division 16 Electrical. Provide electrical connections under Division 16 Electrical. Provide controllers and contactors with maximum of 120-volt control circuits, and auxiliary contacts for use with controls furnished. When motors and equipment furnished are larger than sizes indicated, the cost of providing additional electrical service and related work shall be included under this section.

B. Electrical Work

Provide under Division 16 Electrical. Provide control wiring under Section 15970, "DIRECT DIGITAL CONTROL SYSTEMS".

2.3 METAL DUCT SYSTEMS

Provide shop-fabricated, zinc-coated steel ducts conforming to ASTM A 653/A 653M coating designation G90. Fabricate, construct, brace, reinforce, install, support, and seal ducts and accessories in accordance with SMACNA DCS. Provide rectangular ductwork for low pressure applications; round and flat oval ductwork for medium and high pressure applications as indicated. Cover duct transverse joints with single component synthetic rubber type compound suitable for use with passivated coating on zinc-coated steel. Lap joints in direction of flow. Provide ducts straight and smooth on inside with neatly finished airtight joints. Provide air supply and return openings in ducts with air diffusers, registers, or grilles.

A. Ducts of Pressure Classes 3 to 10 WG

Construction ducts of galvanized steel.

1. Construction

Duct construction, metal gages, and hangers and support reinforcements shall conform with the SMACNA DCS. Ducts shall not pulsate or vibrate when in operation. Pressure sensitive tape shall not be used as a primary sealant on ductwork. Air leakage shall be less than one percent of the system capacity. Curved elbows shall have a centerline radius not less than 1 1/2 times the width of ducts.

2. Joints

Construct joints to meet the requirements of the leakage test specified herein. Duct components shall fit so that joints are not mismatched. Do not use duct sealant and tape to compensate for mismatched connections. Longitudinal locks or seams known as "button-punch snap-lock" will not be permitted. Apply fire-resistant sealing compound to exposed male part of fittings collars so that sealer

will be on inside of joint and fully protected by the metal of the duct and fittings. Apply one brush coat of sealing compound over outside of joint to at least 2 inch band width covering screw heads and joint gap. When tape is used, apply a single wrap of a duct tape over the wet sealer. Tape provided shall be recommended by the sealer manufacturer to permit proper curing of the sealer. Dents in the male portion of the slip fitting collar will not be acceptable.

3. Fittings

Square elbows, round elbows, fittings, branch take-offs, transitions, splitters, duct volume dampers, fire dampers, flexible connections, and access doors shall conform with the SMACNA DCS, Section 2.

- a. Test holes: Provide factory fabricated, airtight, and noncorrosive test holes with screw cap and gasket. Provide extended neck fittings to clear insulation.
- b. Round elbows: Provide 45 degree and 90 degree round elbows of two piece die stamped construction for ducts 8 inches or less in diameter. For ducts over 8 inches in diameter, provide 5 mitered piece for 90 degrees and 3 mitered piece for 45 degrees.

4. Round and Oval Ducts

SMACNA DCS, Section 3.

5. Medium - High Pressure Single Wall, Round And Flat Oval Spiral Duct And Fittings

- a. Gauges and construction per SMACNA Duct Construction Standards - Metal and Flexible.
- b. Fiberglass insulation thickness 1 inch.
- c. Fiberglass liner to have protective membrane on air stream side to provide positive barrier against glass fiber entrainment.
- d. Slip joint construction.
- e. 90 Degree elbows to be 5 piece welded or 2 piece die formed where available.
- f. 45 Degree elbows to be 3 piece welded or 2 piece die formed where available.
- g. Tees and crosses to be conical type.
- h. Take off from rectangular duct to use bell mouth fitting.
- i. Provide from air handling unit discharge to inlet of fan powered mixing terminal.

6. Medium – High Pressure Double Wall, Round And Flat Oval Spiral Duct And Fittings
 - a. Gauges and construction per SMACNA Duct Construction Standards - Metal and Flexible with perforated interior sheet metal wall.
 - b. Fiberglass insulation thickness 1 inch.
 - c. Fiberglass liner to have protective membrane on air stream side to provide positive barrier against glass fiber entrainment.
 - d. Slip joint construction.
 - e. 90 Degree elbows to be 5 piece welded or 2 piece die formed where available.
 - f. 45 Degree elbows to be 3 piece welded or 2 piece die formed where available.
 - g. Tees and crosses to be conical type.
 - h. Take off from rectangular duct to use bell mouth fitting.
 - i. Provide from air handling unit discharge to inlet of fan powered mixing terminal.

7. Medium –High Pressure Rectangular Ducts

Make joints between sections of duct and between ducts and fittings with either gasketed flanged connection, welded flange joints, or other joints recommended in SMACNA DCS, Section 1, and reinforce at the joints and between the joints as recommended. Construction to match connected round and oval duct systems.

B. Ducts of Pressure Classes Up To 3 Inch WG

Construction, metal gage, hangers and supports, and reinforcements shall conform with SMACNA DCS, except that ducts with pressure classifications below 2 inch water gage that are located outside of the conditioned space shall have a seal Class B. Ductwork shall be airtight and shall not vibrate or pulsate when system is in operation. Pressure sensitive tape shall not be used as a primary sealant on ductwork with pressure classifications above one inch water gage. Air leakage shall be less than 5 percent of the system capacity. Construct ductwork of galvanized steel.

1. Curved Elbows

Make a centerline radius not less than 1 1/2 times the width or diameter of the duct.

2. Laps

Make laps at joints in the direction of airflow. Space button-punch or bolt-connection in standing seams at fixed centers not greater than 6 inches. Longitudinal locks or seams, known as "button-punch snap lock," may be in lieu of Pittsburgh Lock.

3. Fittings

Elbows, vanned elbows, take-offs, branch connections, transitions, splitters, volume dampers, fire dampers, flexible connections, and access doors shall conform with SMACNA DCS, Section 2. Provide factory fabricated, airtight, and noncorrosive test holes with screw cap and gasket.

C. Acoustical Attenuator Systems

1. Acoustical Duct Lining

Provide where indicated. Provide ASTM C 1071 fiberglass duct lining, minimum of one inch thick, with black-pigmented fire-resistant coating on side exposed to airstream. Secure to duct interior with 100 percent coverage of adhesive and with mechanical fastening devices, spaced in accordance with SMACNA DCS. Provide metal nosing at duct lining beginnings and endings.

2. Net Noise Reduction Values

Conform with the following:

Minimum Net Noise Reduction Values

Sound Pressure Level dB

(Reference Sound Power at 10-12 Watts)

Octave Pass Band	2	3	4	5	6	7	
Center Frequency (Hz)	125	250	500	1000	2000	4000	
Noises Reduction (db)	11	16	19	30	40	32	

3. Preformed Duct Liner

Provide preformed round duct liner minimum of one inch thick, with black-pigmented fire-resistant, anti-microbial agent designed for insertion in round ducts may be used in the sizes commercially available. Provide duct liner sections with slip-lap joints not less than 2 inches wide. Make joints in accordance with manufacturer's printed instructions. Furnish fire-resistant adhesive to field-coated joints when recommended by the manufacturer to prevent delamination or erosion at joints. Tabular sections of duct liner shall fit the metal duct snugly and without gaps between duct-liner sections.

D. Laboratory / Chemical Fume Hood Exhaust Ducts

1. Stainless steel sheet, ASTM A167, Class 302 or 304, Condition A (annealed) Finish No. 4 for exposed ducts and Finish No. 2B for concealed duct or ducts located in mechanical rooms.

- OR -

2. PVC Coated Duct: Duct internally coated with PVC may be furnished in lieu of stainless steel for laboratory fume hood exhaust duct.
 - a. Duct shall be galvanized sheet steel, ASTM A527, coating G90, coated inside before fabrication with four mil dry film thickness of polyvinyl chloride (PVC) plastic suitable for temperature to 120 degrees C (250 degrees F). Material shall comply with UL 181, Class 1 (flame spread rating of not more than 25 and a smoke developed rating of 50 or less in accordance with ASTM E84). Duct exterior may be uncoated or coated with PVC. Provide compatible joint sealant and material for field coating of damaged areas.
 - b. Damper frames, damper blades and shafts, shall be stainless steel or PVC coated galvanized steel, with non-ferrous bearing material.

E. Flexible Duct Connectors

Provide a minimum of design pressure rated plus 5.0 inch W.G. static pressure airtight flexible duct connectors at duct connections to each air-conditioning unit, air-handling unit, exhaust fan, and ventilating fan. Support connectors at each end with metal angle frame bands, securely bolt in place. Provide not less than 20 ounce glass fabric duct connectors coated on both sides with neoprene.

F. Turning Vanes

Provide fabricated tees and square elbows with double walled turning vanes in accordance with SMACNA DCS for vaned elbows.

G. Dampers

Provide factory manufactured opposed blade adjustable manual dampers where indicated for duct heights of 12 inches and larger. Provide factory manufactured single leaf dampers for duct heights less than 12 inches. Provide damper shafts with 2 inch standoffs to clear 2 inches of duct insulation with bearings at both ends of the shafts. Provide adjustment quadrant with indicator and locking devices. Provide galvanized steel dampers 1 gage heavier 10.006 inch than duct in which dampers are installed.

H. Diffusers, Registers, and Grilles

Provide factory-fabricated metal units with edges rolled or rounded where exposed to view, and factory primed with off-white enamel finish. Provide each diffuser and register with factory-fabricated, group-operated, adjustable, opposed-blade, air-volume-control dampers, key or screwdriver operated from the face of unit. Provide each unit with

rubber or plastic installation gaskets. Diffusers in same room shall have same face design.

1. Diffusers: Provide round, square, or rectangular diffusers as indicated. Ceiling diffusers shall be designed to deliver air in a horizontal direction. Provide baffles or other devices as required for proper air distribution pattern. Provide 4-way pattern unless otherwise noted on contract drawings.
2. Registers: Provide double deflection supply registers arranged to control air direction, throw, and drop. Exhaust and return air registers shall have single set of nondirectional face bars or vanes having the same appearance as supply registers. Provide face bars or vanes spaced not more than 0.75 inch on center and not less than 0.62 inch depth.
3. Grilles: Provide as specified for registers without air-volume-control dampers.

I. Access Doors

Provide for access to volume dampers, fire dampers, plenum chambers, and where indicated. Provide each door with double wall zinc-coated steel construction, gasketed airtight, with continuous hinges and cam latches. Insulate access doors with one inch thick rigid insulation. Provide 12 inch by 12 inch door, except where larger sizes are indicated, or provide 12 inches by height of duct when duct is less than 12 inches high. Provide keyed-alike 90 degree turn cam locks on each access door in sleeping rooms; furnish three keys.

J. Fire Dampers

UL 555 and NFPA 90A. Dampers shall be listed in UL BMD. Dampers when open shall not protrude into the ducts. Dampers shall be dynamic rated.

K. Flexible Round Ducts (see Execution section for limitations on use)

UL 181 and NFPA 90A with factory-applied insulation, vapor barrier, and end connections. Fire hazard rating of duct assembly shall not exceed 25 for flame spread and 50 for smoke developed. Provide ducts designed for working pressures of 2 inches W.G. positive and 1.5 inches W.G. negative. Flexible round duct length shall not exceed 5 feet. Secure connections by applying adhesive for 2 inches over rigid duct, apply flexible duct 2 inches over rigid duct, apply metal clamp, and provide minimum of three No. 8 sheet metal screws through clamp and rigid duct.

1. Inner duct core: Flexible core shall be interlocking spiral or helically corrugated and constructed of zinc-coated steel, aluminum, or stainless steel; or shall be constructed of inner liner of continuous galvanized spring steel wire helix fused to continuous, fire-retardant, flexible vapor barrier film, inner duct core.
2. Insulation: Inner duct core shall be insulated with mineral fiber blanket type flexible insulation, minimum of 1 inch thick. Insulation shall be covered on exterior with manufacturer's standard fire retardant vapor barrier jacket for flexible round duct.

2.4 PIPING SYSTEMS

Provide the following pipe and fittings. Provide dielectric fittings, unions or flanges between steel piping and copper tubing for all piping sizes; except that copper alloy valves and strainers may be used without dielectric fittings, unions or flanges. Water piping sizes 4 inches and smaller shall be copper tubing. Water piping sizes larger than 4 inches shall be copper tubing or steel piping.

A. Soldered Joint Copper Tubing

Provide ASTM B 88, Type L or M for aboveground piping, Type K for buried piping, with ANSI B16.18 or ASME/ANSI B16.22 solder joint fittings, unions, and flanges; provide adapters as required. Provide ASTM B 42 copper pipe nipples with threaded end connections. Provide ASTM B 32, 95-5 tin-antimony solder, or provide Plumbing Code approved lead-free solder.

B. Grooved-End Copper Tubing System

Grooved-end copper tubing system may be provided in lieu of soldered joint copper tubing for water piping located within the mechanical equipment rooms and aboveground exterior of the buildings for pipe sizes 2 through 6 inches. Provide grooved-end mechanical couplings of the rigid type including EPDM gaskets and copper fittings supplied by the same manufacturer for pipe sizes 2 through 6 inches.

1. Copper Tubing

ASTM B 88, Type M with rolled grooved end connections.

2. Copper Fittings

Copper alloy shall conform to ASTM B 75 C12200, ASTM B 152 C11000, ANSI B16.18, or ASME/ANSI B16.22 for factory rolled grooved copper alloy tees, elbows, and reducers.

3. Gasketed Mechanical Couplings

ASTM F 1476 for use with rolled grooved copper tubing and rolled grooved copper alloy fittings. Provide ASTM A 536 rigid type couplings which do not permit expansion or contraction, EPDM gaskets, and ASTM A 183 bolts and coupling nuts. Provide flanged adapters as required for connections to ASME Class 125 and 150 flanges on valves and equipment.

C. Copper Tubing Piping Systems

Provide copper tubing for the following piping systems, except water piping sizes larger than 4 inches shall be copper tubing or steel piping.

1. Chilled water, chilled-hot water, and hot water piping.

2. Cold drain piping from drain pans.

3. Fuel oil supply and return piping with ASME/ANSI B16.26 flared fittings or compression type fittings.

D. Copper Cold Drain Piping

Provide copper tubing in accordance with paragraph entitled "Copper Tubing" for Piping Sizes One Inch and Smaller." Provide ASTM B 306 copper tubing and ANSI B16.23 solder joint fittings for piping sizes larger than one inch. In lieu of copper tubing, 1.25 inch Schedule 40 polyvinyl chloride (PVC) plastic pipe, fittings, and solvent cement may be provided.

E. Copper Refrigerant Tubing

Provide ASTM B 280, cleaned, dehydrated, and sealed. Provide ASME/ANSI B16.22 solder joint refrigerant fittings and adapters. Provide silver brazing alloy solder and silver brazing alloy flux. During brazing operations bleed a small amount of dry oil-free nitrogen continuously through the refrigerant tubing. Provide ASME/ANSI B16.26 flared fittings.

F. Dielectric Connections

Provide at connections between copper and ferrous metal piping materials. ASTM F 441/F 441M, Schedule 80, CPVC threaded pipe nipples, 4 inch minimum length, may be provided for dielectric connections in pipe sizes 2 inches and smaller.

G. Valves

Valves shall have flanged end connections, except valves smaller than 2.5 inches may have threaded end connections with a union on one side of the valve. Solder end connections may be used for connections between copper alloy valves and copper tubing.

1. Gate Valves

MSS SP-80, Class 125, except sizes 2.5 inches and larger shall conform to MSS SP-70, Class 125.

2. Globe and Angle Valves

MSS SP-80, Class 125, except sizes 2.5 inches and larger shall conform to MSS SP-85, Class 125.

3. Check Valves

MSS SP-80, Class 125, swing check; except sizes 2.5 inches and larger shall conform to MSS SP-71, Class 125.

4. Butterfly Valves

MSS SP-67, except sizes 2.5 inches and larger shall have lugged or wafer body designed for installation between ASME Class 150 flanges. Valves shall have two-position lever handles.

5. Ball Valves

Full port design, copper alloy body, except sizes 2.5 inches and larger shall be cast-iron body. Valves shall have two-position lever handles. Ball valves may be provided in lieu of gate valves.

6. Square Head Cocks

Provide copper alloy or cast-iron body with copper alloy plugs, suitable for 125 psig water working pressure.

7. Air Venting Valves

Provide copper alloy body valves with automatic or manual air vent as indicated.

H. Specialty Valves

1. Combination Pressure and Temperature Relief Valves

ANSI Z21.22, copper alloy body, automatic reseating, test lever, and discharge capacity based on AGA temperature steam rating.

2. Water Pressure Reducing Valves

ASSE 1003, copper alloy body, automatic reseating, with test lever.

3. Water Temperature Regulating Valves

Provide copper alloy body, direct acting, pilot operated, for the intended service.

4. Flow Control Balancing Valves

Copper alloy or cast iron body, copper alloy or stainless internal working parts, and integral pointer that indicates the degree of valve opening. Valves shall be suitable for 125 psig at 190 degrees F hot water. Valve shall function as a service valve when in fully closed position. Valve body shall have factory-installed tapings for differential pressure meter connections for verification of pressure differential across valve orifice. Meter connections shall have positive check valves or shutoff valves. Each valve shall have metal tag showing the gallons per minute flow for each differential pressure reading.

5. Backflow Prevention Assemblies

Provide reduced pressure principle type backflow prevention assemblies which are approved by and has a current "Certificate of Approval" from the FCCCHR-USC. Listing of the particular make, model/design, and size in the current FCCCHR-USC will be acceptable as the required proof.

6. Refrigerant Valves

ASME/ANSI B31.5, and shall be copper alloy. Provide valves in each system for servicing and for isolating system components in compliance with ASHRAE 15.

2.5 PIPING ACCESSORIES

A. Pipe Hangers and Supports

Provide MSS SP-58 and MSS SP-69, Type 1 with adjustable type steel support rods, except as specified or indicated otherwise. Attach to steel joists with Type 19 or 23 clamps and retaining straps. Attach to Steel W or S beams with Type 21, 28, 29, or 30 clamps. Attach to steel angles and vertical web steel channels with Type 20 clamp with beam clamp channel adapter. Attach to horizontal web steel channel and wood with drilled hole on centerline and double nut and washer. Attach to concrete with Type 18 insert or drilled expansion anchor. Provide Type 40 insulation protection shield for insulated piping.

B. Strainers

Pressure and temperature range shall be for the intended service. Provide blowoff outlet with pipe nipple, gate valve, and discharge pipe nipple. Provide stainless steel strainer element with perforations of 0.047 inch for water, 0.031 inch for steam mixed with condensate, and 0.016 inch for steam. Provide copper alloy or cast-iron body strainers in steam and condensate systems up to 100 psig. Provide steel body strainers in steam and condensate systems 100 psig and greater.

C. Traps

Provide traps of the types indicated with stainless steel internals. Pressure and temperature range shall be for the intended service. Traps for steam at 100 psig and greater shall be minimum of ASME Class 150.

D. Pressure Gages

Provide single style pressure gage with 4.5-inch dial, brass or aluminum case, bronze tube, gage cock, pressure snubber, and syphon. Provide scale range for intended service.

E. Thermometers

Provide bi-metal dial type thermometers with stainless steel case, stem, and fixed thread connection; 3 inch diameter dial with glass face gasketed within the case; and accuracy within 2 percent of scale range. Provide scale range for intended service.

F. Pipe Sleeves

Provide where piping passes entirely through walls, ceilings, roofs, and floors. Secure sleeves in position and location during construction. Provide sleeves of sufficient length to pass through entire thickness of walls, ceilings, roofs, and floors. Provide 1-inch minimum clearance between exterior of piping or pipe insulation, and interior of sleeve or core-drilled hole. Firmly pack space with mineral wool insulation. Seal space at both ends of sleeve or core-drilled hole with plastic waterproof cement which will dry to a firm but pliable mass, or provide a mechanically adjustable segmented elastomeric seal. In fire walls and fire floors, seal both ends of sleeves or core-drilled holes with UL listed fill, void, or cavity material.

1. Sleeves in Masonry and Concrete

Provide steel pipe sleeves or Schedule 40 PVC plastic pipe sleeves. Sleeves are not required where drain, waste, and vent (DWV) piping passes through concrete floor slabs located on grade. Core drilling of masonry and concrete may be provided in lieu of pipe sleeves when cavities in the core-drilled hole are completely grouted smooth.

2. Sleeves not in Masonry and Concrete

Provide 26 gage galvanized steel sheet or PVC plastic pipe sleeves.

G. Flexible Pipe Connectors

Provide flexible bronze or stainless steel piping connectors with single braid where indicated. Connectors shall be suitable for the intended service.

H. Sight Glass and Refrigerant Drier

ARI 710. Provide in refrigerant liquid piping.

2.6 ACCESS DOORS FOR VALVES

Provide factory-prefabricated and primed flush face steel access doors including steel door frame for with continuous hinges and turn-screw-operated latch. Provide door frame installation in plaster and masonry walls. Furnish doors under this section; install doors under appropriate section of this specification.

PART 3 - EXECUTION

3.1 INSTALLATION

A. HVAC System

Installation of HVAC system including equipment, materials, installation, workmanship, fabrication, assembly, erection, examination, inspection, and testing shall be in accordance with ASME B31.1, ASME/ANSI B31.5, NFPA 70, and in accordance with the manufacturer's recommendations.

B. Connections to Existing Systems

Notify the Owner's Representative in writing at least 15 calendar days prior to the date the connections are required. Obtain approval before interrupting service. Furnish materials required to make connections into existing systems and perform excavating, backfilling, compacting, and other incidental labor as required. Furnish labor and tools for making actual connections to existing systems.

3.2 PIPING

Test, inspect, and approve piping before burying, covering, or concealing. Provide fittings for changes in direction of piping and for connections. Make changes in piping sizes through tapered reducing fittings; bushings will not be permitted. Install valves with stems horizontal or above.

Provide flanges or unions at valves, traps, strainers, and connections to equipment; unions are not required in copper tubing piping systems.

- A. Threaded connections: Provide Teflon pipe thread paste on male threads. Do not thread metal pipe into plastic piping.
- B. Pipe hangers and supports: Provide additional pipe hangers and supports at in-line water pumps and flanged valves.
- C. Piping to receive insulation: Provide temporary wood spacers between the pipe hangers and supports, and the pipe to properly slope the piping and establish final elevations. Provide temporary wood spacers of same thickness as insulation to be provided under Section 15250, "INSULATION". Support plastic piping every 4 feet. Support metal piping as follows:

MAXIMUM SPACING (FEET)

Nominal Pipe Size (inches)	One and under	1.25	1.5	2	2.5	3	3.5	4	5	6
Copper Tubing	6	7	8	8	9	10	11	12	13	14
Steel Pipe	7	8	9	10	11	12	13	14	16	17

- D. Cleaning of piping: Keep interior and ends of new piping and existing piping affected by Contractor's operations, cleaned of water and foreign matter during installation by using plugs or other approved methods. When work is not in progress, securely close open ends of pipe and fittings to prevent entry of water and foreign matter. Inspect piping before placing into position.
- E. Demolition: Remove materials so as not to damage materials which are to remain. Replace existing work damaged by Contractor's operations with new work of same construction.
- F. Tee Joints: Extracted tee joints may be made in copper tube. Make joint with an appropriate tool by drilling a pilot hole and drawing out the tube surface to form a collar having a minimum height of three times the thickness of the tube wall. To prevent the branch tube from being inserted beyond the depth of the extracted joint, provide dimpled depth stops. Notch the branch tube for proper penetration into fitting to ensure a free flow joint. Braze extracted joints using a copper phosphorous classification brazing filler metal. Soldered joints shall not be permitted.
- G. Tracer Wire
Provide metallic tracer wire for all underground buried piping.

3.3 ADJUSTMENTS

Adjust controls and equipment so as to give satisfactory operation. Adjust entire water temperature control system and place in operation so that water quantities circulated are as indicated. Air duct systems shall be adjusted and balanced so that air quantities at outlets are as

indicated and so that distribution from supply outlets is free from drafts and has uniform velocity over the face of each outlet.

3.4 INSTRUCTING OPERATING PERSONNEL

Upon completion of work and at time designated by Owner's Representative, provide services of competent technician for period of not less than one 8-hour working day for instruction of Government operating personnel in proper operation and maintenance of equipment.

3.5 FIELD QUALITY CONTROL

Upon completion and before final acceptance of work, test each system in service to demonstrate compliance with the contract requirements. Adjust controls and balance systems prior to final acceptance of completed systems. Test controls through every cycle of operation. Test safety controls to demonstrate performance of required function. Correct defects in work provided by Contractor and repeat tests. Furnish steam, fuel, water, electricity, instruments, connecting devices, and personnel for tests. Flush and clean piping before placing in operation. Clean equipment, piping, strainers, ducts, and filters.

A. Piping Systems Except for Refrigerant Piping

Before insulating, hydrostatically test each new piping system at not less than 188 psig; except pneumatically test fuel oil storage tank and fuel piping system at not less than 5 psig for tank and 50 psig for piping. Maintain pressure for 2 hours with no leakage or reduction in gage pressure. Obtain approval before applying insulation.

B. Refrigerant Piping

Perform following when field piping connections are provided.

1. Pressure test: Test refrigerant piping using dry, oil-free nitrogen, and prove tight at 300 psig on the high side and 150 psig on the low side. Maintain pressure for 2 hours with no leakage or reduction in gage pressure.
2. Evacuation: Using high vacuum pump and certified micron gage, reduce absolute pressure on both sides of system simultaneously to 300 microns. After reaching this point charge system with proper refrigerant until pressure of zero psig is obtained. Repeat evacuation-charging procedure for two more cycles, totaling to three evacuation-charging cycles. On final evacuation, secure pump and maintain 300 microns for 2 hours before charging with required final refrigerant.

C. Air Ducts

Obtain approval before applying insulation.

1. Connect ceiling supply diffusers to low pressure duct with a maximum of 5 feet of flexible duct. Ensure smooth radius bends with proper support. Other uses of flexible duct are not permitted.

D. Equipment

1. Field Testing

Test each item of equipment in operation for continuous period of not less than 24 hours under every condition of operation in accordance with each equipment manufacturer's recommendation. Verify that the equipment operating parameters are within limits recommended by the manufacturer.

2. Equipment Requiring Field Test Plans

Furnish equipment field test plans developed by each equipment manufacturer detailing recommended field test procedures for each item of equipment. Field test plans developed by the installing Contractor, or the equipment sales agency furnishing the equipment will not be acceptable. The Owner's Representative will review and approve the field test plan for each item of equipment prior to commencement of field testing of the equipment.

- a. Equipment items to test: Equipment requiring field test plans are listed in paragraph entitled "Statements."
- b. Coordinated testing: Indicate in each field test plan when work required by this section requires coordination with test work required by other specification sections. Furnish test procedures for the simultaneous or integrated testing of equipment controls which interlock and interface with controls factory prewired or external controls for the equipment provided under Section 15970, "DIRECT DIGITAL CONTROL SYSTEMS".
- c. Prerequisite testing: Equipment for which performance testing is dependent upon the completion of the work covered by Section 15030, "ADJUSTING, BALANCING AND SYSTEM TESTING" must have that work completed as a prerequisite to testing work under this section. Indicate in each field test plan when such prerequisite work is required.
- d. Test procedure: Indicate in each field test plan each equipment manufacturers published installation, start-up, and field acceptance test procedures. Include in each test plan a detailed step-by-step procedure for testing automatic controls provided by the manufacturer. Each test plan shall include the required test reporting forms to be completed by the Contractor's testing representatives. Procedures shall be structured to test the controls through all modes of control to confirm that the controls are performing with the intended sequence of control. Controllers shall be verified to be properly calibrated and have the proper set point to provide stable control of their respective equipment.
- e. Performance variables: Each test plan shall list performance variables that are required to be measured or tested as part of the field test. Include in the listed variables performance requirements indicated on the equipment schedules on the design drawings. Manufacturer shall furnish with each test procedure a description of acceptable results that have been verified. Manufacturer shall identify the acceptable limits or

tolerances within which each tested performance variable shall acceptably operate.

- f. Job specific: Each test plan shall be job specific and shall address the particular item of equipment and particular conditions which exist with this contract. Generic or general preprinted test procedures are not acceptable.
- g. Specialized components: Each test plan shall include procedures for field testing and field adjusting specialized components, such as hot gas bypass control valves, or pressure valves.

3. Equipment Requiring Field Test Reports:

- a. Equipment items for reports: Equipment requiring field test reports are listed in paragraph entitled "Field Test Reports."
- b. Manufacturer's recommended test: Conduct the manufacturer's recommend field testing in compliance with the approved test plan. Furnish a factory trained field representative authorized by and to represent the equipment manufacturer at the complete execution of the field testing.
- c. Operational test: Conduct a continuous 24 hour operational test for each item of equipment. Equipment shutdown before the test period is completed shall result in the test period being started again and run for the required duration. For the duration of the test period, compile an operational log of each item of equipment. Log required entries every two hours. Use the test report forms for logging the operational variables.
- d. Notice of tests: Conduct the manufacturer's recommended tests and the operational tests; record the required data using the approved reporting forms. Notify the Owner's Representative in writing at least 15 calendar days prior to the testing. Within 30 calendar days after acceptable completion of testing, submit each test report for review and approval.
- e. Report forms: Type data entries and writing on the test report forms. Completed test report forms for each item of equipment shall be reviewed, approved, and signed by the Contractor's test director and the QC manager. The manufacturer's field test representative shall review, approve, and sign the report of the manufacturer's recommended test. Signatures shall be accompanied by the person's name typed.
- f. Deficiency resolution: The test requirements acceptably met; deficiencies identified during the tests shall be corrected in compliance with the manufacturer's recommendations and corrections retested in order to verify compliance.

END OF HEATING, VENTILATING, AND COOLING SYSTEM